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ABSTRACT

An educational system should attempt to provide four services: (1) skill acquisition for students, (2) competent citizens for society, (3) a balance between the supply and demand for educated persons, and (4) maximum quality education at minimal cost. Since performance in school is often used as a screening device in career choice, care should be taken to ensure than testing is fair and scientific. The need for trained personnel can be assessed using two approaches, manpower planning and demand-for-places. A measure of efficiency can be derived by comparing total years of studies and resources expended with outcomes of the system. This article contains a brief discussion of the criteria for assessing quality education, including an appendix on measuring wastage in education. (EMH)

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Werdelin, I.:

ON THE QUALITY OF THE EDUCATIONAL SYSTEM AS SEEN FROM THE POINT OF VIEW OF EDUCATIONAL STATISTICS

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ON THE QUALITY OF THE EDUCATIONAL SYSTEM AS SEEN FROM THE POINT OF VIEW OF EDUCATIONAL STATISTICS

Abstract. - The article contains a brief discussion of various facts which must be considered when we judge the quality of a school system: It must provide the education which is suited to the individual, and it must provide educated personnel to society at so low cost as possible. Methods of improving this quality are discussed. In an appendix a method of measuring wastage in education is presented.

I. GENERAL DISCUSSION

The concept of the quality of an educational system can be considered from several standpoints, depending on what is meant by this expression. Educational statistics would prefer to look at it from the bird´s point of view: Is the educational system functioning properly? This involves a number of sub-problems, of which the author will briefly discuss those he considers the most important ones.

An educational system can be compared with a large factory or industry: Into the system we feed the students we want to train, we invest money and effort in their training, and we get a result in the form of graduates and other trained persons. A factory or another industry would not function properly unless one considered such factors as the relationships between supply and demand and between input and output. That a school system should be considered an industry is perhaps not quite clear to all educationalists. Many of these would certainly prefer to talk about the quality of the educational system in terms of the qualifications of its graduates.

In order to show high quality, an educational system must have the following characteristics:
(1) It must provide such an education to the residents in the country that these can get the type of occupation for which they are best suited.
(2) It must provide educated and trained personnel to society at large.
(3) It must be such that it secures a proper balance between the number of trained or educatied persons available in each field or sector and the number of trained or educated persons available.
(4) It must be efficient, i.e. it must do its work at as low a cost as possible.

Both to the individual, who receives schooling which allows him to enter a new school or a profession, and to society, which accepts the individuals who shall hold jobs, the real qualifications given by the education or training is most essential. It is probably generally true that further education and training will make the individual still more efficient in his job, but further education costs money. Probably there is an optimum point in the function for the relationship between efficiency in the job and cost of training for it. We should aim at being as close as possible to this point. How to find it is a difficult problem, of course, which can perhaps be solved only by means of such statistical methods as decision theory. In most cases we might be satisfied with not being below a certain level of education. For the quality of the

educational system, a stable minimum qualification level of graduates is therefore essential.

In order to guarantee that we get the best possible persons, we need some instrument of selection, and in order to make certain that students are channeled into the type of education or training which will lead them to the occupation for which they are most suited, we also need some form of instrument. This means that the proper functioning of the educational system depends on our having valid instruments which enable us to make appropriate personnel decisions. In various school systems instruments like school marks and tests are used; various measures of the ability to profit from education are common criteria for selection. It should not be forgotten that the social or economic status of the student's family also often serves as such an instrument. Performance in school is often used for the selection of persons for jobs.

One purpose of all measurement in education must be to arrive at decisions about the future vocational choices of individuals, either directly or indirectly through choices of lines of study. These decisions can be made as seen from the individual's point of view or as seen from the point of view of society. In all individual decision a student has to make a choice between those vocations or lines of study which are open to him, taking into account known facts in the choice situation as well as his personal set of values. Only some of the aspects which influence this choice are measurable. When society or an institution in this society makes decisions as to the selection of workers or students, the total effect of a series of decisions can be taken into account. Usually it is a question of decision in a group situation. In properly carried out selection of persons for employment or further training, only measurable aspects should be taken into account. The effect of the selection should be to arrive at a situation which maximizes the total benefit for society or the institution (or which minimizes drawback). A theory of psychological and educational measurement has been developed to aid us in this selection. Its most advanced aspects have their foundation in statistical decision theory. In this article we cannot discuss this, of course, but refer to e.g. the work by Cronbach and Gleser (1965).

Unfortunately, much personnel decision and selection is carried out on an unscientific basis, and personal value systems and subjective factors enter into decisions which shall be made for the benefits of society. This is a situation which greatly hampers development and lowers the quality of the educational system. - The relationship between level and type of education and efficiency in a certain job is not always known. The question of how to select individuals for certain lines of schooling or certain jobs has not generally been answered, either. In most cases the instruments we use for selection show low validity. This means that we make mistakes when selecting people. Many of the students who enter school will prove unsuited for this type of education or this line of study, and many persons who enter a job will turn out to be unsuited for this. To reduce the number of mistakes and increase the efficiency of our decisions, it is essential that we use whatever instruments are available. We must try to improve the validity of our instruments, and much research on personnel decision is needed.

There are two ways of projecting needs for education in a country: (1) By estimating the future needs for persons with a certain educational background, i.e. by projecting the future manpower situation, and (2) by estimating the future number of students who will enter and pass through the school system under the assumption that the educational development will not be greatly influenced by outer factors like changing educational policy. The former approach is called the manpower approach, the latter the demand-for-places approach. Balance between access of educated personnel and need for such personnel can evidently usually only be acquired through accurate manpower projections, but nevertheless the demand-for-places approach is by far the most common one.

The manpower approach uses the estimated required future output from the educational system as its starting point. Still estimates of the future demand for education seem to be based on a fairly undeveloped theory. Generally speaking, existing methods are based on the assumption that there is a simple relationship between estimated G.N.P. in a certain industrial sector and the stock of education to be found there. This is not the proper place for a summary of existing methods in the field, nor for a discussion of the pros and cons of such methods. - From the targets which have been fixed for the development of an industrial sector it is possible to estimate future needs for the education of personnel within the sector; by adding together for all sectors we can estimate the future required output each year from each line or branch of the educational system. From the output needed and the assumed relationship between the number of entrants and the output, it is possible to estimate the number of entrants each year as well as the total number of students, costs, etc.

The demand-for-places approach starts from estimates of the number of entrants each year. This number is found as a function of population figures, economic data, etc. From this projected number and projected data about dropping-out and repetition etc. it is possible to estimate the output from the educational system. The method is based on assumed relationships between data about entrants, drop-outs, and repeaters and outer data. The functions used are not always very accurate. This method of projection does not take manpower need into account. In most cases educational planning is based on the fundamental assumption that educational institutions shall be allowed to develop according to demand for places, and educational shall be provided according to the free choices of the population.

For sound economic planning and efficient allocation of resources it is essential that students are selected on the basis of estimated needs for educated personnel. Even if we are still far from being able to make accurate estimates, it is more likely to give satisfactory results, particularly if it is combined with the best available methods for personnel decisions. In countries where students are allowed to enter the field of their choice, we often find lack of personnel in certain areas at the same time as we have unemployed persons in other areas. Particularly often such important fields as the manufacturing industries lack people in the middle manpower sectors, while too many students enter humanistic lines. As this is not a technical report, we cannot discuss methods of manpower assessment. A recent report edited by the OECD Directory of Scientific

Affairs (1966) discussed consequences of the various approaches as well as methods of estimating educational needs. Manpower analysis is also treated in works by Correa (1965), Parnes (1963), and Hollister (1966).

The aspects of the quality of an educational system we have discussed in the above concern the selection of students for schooling and the need for educated personnel. As another important aspect we have to consider the efficiency with which the system works; the effort we must invest in the individual student to bring him to graduation or make him able to handle a job. This efficiency depends on many factors, e.g. the qualifications of teachers, the amount of equipment available, teaching methods used, educational policy, etc. Most of these aspects are very well known and very much discussed in other works, primarily educational and psychological ones, and therefore they do not need being discussed in this short paper. Allow me to concentrate on one statistical aspect, namely the effect of the educational policy with regard to graduation, promotion, dropping-out and repetition of students.

It is a well-known fact that different countries, different units within the school system of a country, and even different teachers demand differently much from their students in the course of a school year. In a few cases we find that elementary schooling is compulsory and promotion automatic. In other cases we find that some students drop out from the school system in each grade, while others repeat. In all cases we find, however, that promotion is considered normal and dropping-out and repetition unfortunate events. That certain students are allowed to repeat or forced to leave the school system is usually due to the fact that teachers are supposed to secure a certain level of performance from their graduates. (Some students drop out for economic or other reasons, of course.) The higher the performance level called for, the higher the repetition rates and dropping-out rates.

The fact that certain students drop out while others repeat means that the cost per graduate will be higher than it would have been if all students had been automatically promoted from one grade to the next higher one. A statistically satisfactory method of measuring wastage in education has been discussed elsewhere by the author (1965, 1966) and will be briefly described in Section II below. In order to illustrate the problem and make the following discussion clear, we will here present a simplified example.

In the example it will be taken for granted that the qualifications of the individual students are controlled, so that a student whose knowledge or ability falls below a certain fixed level fails and is forced either to repeat a grade or to drop out. It is assumed that this level of quality of the individual is independently determined and should not be influenced by changes in the educational system.

Let us assume that 1000 students enter grade 1 in a 6-year cycle in a school system. Let us also assume that 20 per cent of all students drop out from each grade, 20 per cent repeat each grade, while 60 per cent are properly promoted or graduate. This will give us a situation which is not unlike the one we find in most developing countries. Of the 1000 students who were in grade 1 in the first year,

600 will be found in grade 2 in the next year, 200 will still be in grade 1 (repeaters), while 200 will have left school.

It can be found that under these assumptions only 179 of the 1000 students will ever graduate. 250 will drop out from grade 1, 188 from grade 2, 141 from grade 3, 79 from grade 4, and 58 from grade 5. If we compute the total number of years studied by each student, we get 4109. This is a measure of the total effort devoted to the education of the 1000 original students.

It might be of interest to compare the total number of years studied with the output of the system. If we assume that education is of value only in so far as it results in graduation, the number of years studied per graduate would indicate effort in relation to output. In our hypothetical case we get 23 years studied per graduate. Even if we hold the view that education which does not result in graduation is of some value, it is obvious that the effort we must invest in education in a system that allows dropping-out and repetition is much greater than the one invested in a system where education is compulsory and promotion automatic. The efficiency of a system with high dropping-out rates and high repetition rates is low. Its quality as a system is low, because it is unable to provide proper education without loss of students, and costs are high.

There is no doubt that if we need to invest much money and great effort in each graduate or each trainee, this is an obstacle to the educational development. In most developing countries comparatively unfavorable figures are found already for elementary school, while unfavorable figures are nearly always found for secondary and higher education. It is certainly clear to everybody that we must aim at an educational system which is as efficient as possible, which gives as high an output as possible in the form of graduates and other educated persons for the money and effort put in. We cannot manipulate dropping-out and repetition at will, however, as they are closely related to the standard of the groups of persons who pass the various grades.

Various ways of increasing the efficiency of the school system with respect to dropping-out and repetition have been tried out, of which we may mention the following:

(1) You can increase the efficiency of the learning situation by providing better trained teachers, by using more and better equipment, and by following modern scientifically based methods of instruction. The increase must be slow, however. The effect of such steps cannot be unlimited either, since we depend on the human material we get and we cannot increase its quality. That improved methods should be used is evident, however. We should invest money and effort in these till we reach the optimum point in the function of the relationship between money and effort invested in and output from the educational system.

(2) You can prolong the period of study for a cycle without increasing the amount to be learned. If the period of study is prolonged it is probable that a larger proportion of the students are able to complete courses and a smaller number of them have to repeat. Also here there is probably an optimum point in the function of the relationship between investment and output and we shall aim at it.

(3) You can differentiate between the students on the basis of their abilities and put them in different classes or groups within each class where they are allowed to work at their own speed and according to their own abilities. In this way it might be possible to prevent dropping-out and diminish or even abolish repetition. The basis for such a differentiation must be thorough knowledge of the qualifications of each individual student, acquired through school marks, tests, etc. Decisions about his placement must be made on the basis of all known facts, given their proper weight. This once more points to the use of measurement and decision theory when we want to make the school system as efficient as possible.

There are educators who defend dropping-out and repetition on the basis that these factors ensure a certain balance between the educational output and needs for educated personnel. If dropping-out and repetition are reduced, we must determine the number of persons who enter certain lines on the basis of estimated needs for graduates or trainees. For the categories for which there is no present need we must either find new forms of schooling, which meet needs in society, or confine ourselves to formal schooling without regard to needs.

To understand and measure the quality of the educational system we must consider a set of factors, of which some essential ones have been mentioned here, and we have to use a set of methods, some statistical and some from the behavioral sciences. For the creation of an efficient school system we must base our policy on estimated needs for educated personnel and select students by means of the best available methods of personnel selection. We must also use these to channel students to the proper line of study. There must be a proper balance between factors like repetition, length of study for a certain aim, and money invested in teacher training and equipment, etc. We are certainly still a long step from such a school system even in advanced countries.

II. TECHNICAL NOTE ON THE MEASUREMENT OF WASTAGE

The number of students in a certain school system depends on three factors: (1) Only some of the students remain in the school system from one year to the next one, while others drop out without having completed school or leave after graduation. (2) Of those who remain in school only some are promoted to the next grade while others repeat the grade. (3) Each year a number of students enter the school system, usually its first grade. - If we have complete information about these three factors we are able to compute the distribution of students in our whole school system. We will deduce two fundamental equations, which tie these factors together. After that we will show how the equations can be used for the measurement of wastage in education.

Let us use the following notations: N_1^0 is the number of students enrolled in grade 1 at the beginning of the year 0, N_2^0 is the number of students enrolled in grade 2 at the beginning of the year, 0, N_3^2 is the number of students enrolled in grade 3 at the beginning of the year 2, and so on. (The lower index figure thus indicates grade, the upper one indicates year.)

But of the N_1^0 students who were enrolled in grade 1 at the beginning of the year 0 not all will remain in school at the beginning of the year 1. Let us use w_1^0 to denote the proportion that remains in school. The total number N_1^0 can thus be divided into two parts:

$$N_1^0 \; w_1^0 \; ,$$

those who will reamin in school at the beginning of the school year 1, and

$$N_1^0 \; (1 - w_1^0) \; ,$$

those who will leave before the beginning of the new school year.

But some of those who remain in school are promoted to the next grade, and the rest are forced to repeat grade 1. Let us use p_1^0 to denote the proportion of those in school who are promoted. The total number N_1^0 has now been divided into three parts:

$$N_1^0 \; w_1^0 \; p_1^0 \; ,$$

those promoted to grade 2,

$$N_1^0 \; w_1^0 \; (1 - p_1^0) \; ,$$

those repeating grade 1, and

$$N_1^0 \; (1 - w_1^0) \; ,$$

those who have left school.

In addition to those who repeat grade 1, this grade will also receive a number of entrants at the beginning of the year 1. This number is denoted by M^1. The total number of students in grade 1 at the beginning of the year 1, N_1^1, is accordingly:

$$N_1^1 = N_1^0 \; w_1^0 \; (1 - p_1^0) + M^1 \; ,$$

and for an academic year in general, z, we have:

$$N_1^{z+1} = N_1^z \; w_1^z \; (1 - p_1^z) + M^{z+1} \; .$$

This is our first fundamental equation.

Grade 2 will receive students from two sources at the beginning of the year 1: those repeating the grade and those promoted from grade 1. The former number is evidently:

$$N_2^0 \; w_2^0 \; (1 - p_2^0) \; ,$$

where the meaning of the notations w_2^0 and p_2^0 is obvious. The latter has been computed before; it is

$$N_1^0 \; w_1^0 \; p_1^0 \; .$$

The total number of students in grade 2 at the beginning of the year 1 will evidently be:

$$N_2^1 = N_2^0 \, w_2^0 \, (1 - p_2^0) + N_1^0 \, w_1^0 \, p_1^0 .$$

This formula can be generalized for any grade k and any academic year z. If we use the notations:

w_k^z = the proportion of those registered in school in grade k at the beginning of the year z who will remain in school in grade k or grade k+1 at the beginning of the year z+1,

p_k^z = the proportion of those registered in school in grade k at the beginning of the year z and still left in school at the beginning of the year z+1 who are promoted to grade k+1;

we get the number of students in grade k at the beginning of the year z+1:

$$N_k^{z+1} = N_k^z \, w_k^z \, (1 - p_k^z) + N_{k-1}^z \, w_{k-1}^z \, p_{k-1}^z .$$

This is our second fundamental equation.

In order to be able to judge the efficiency of a school system, we need to know certain facts. Of a certain number of entrants, how many will ever graduate? If a certain number enters, how many years will these need to study altogether? What will be their average number of years of study?

The best method of measuring the efficiency of a school system, or its opposite, the wastage, would evidently be to select a closed and defined group of children who enter into the first grade of the school system, and study their history as long as they remain in school. We could see how the number of members in the group diminishes and how some are promoted while others repeat classes. That existing data rarely permit such a procedure is evident, but research projects have been carried out according to this model. In practice we can at best get the following data for each grade: the total number of students at the beginning of a certain academic year, and the distribution of these students on three groups: those who drop out of school, those who repeat the same grade, and those who are promoted to the next higher grade. If data are complete for the whole cycle, we can compute the number of students in each grade as well as the number of graduates. The rates w_k^z and p_k^z can easily be computed, too.

From our fundamental equations we can get formulas which allow us to measure wastage in the school system. Let us imagine that we have a school system where the same number of students, M, always enters the first grade of the cycle we are studying. We also suppose that the set of rates of students who remain in school, w_k^z, and the set of rates of promotion, p_k^z, are constant and known. If this is the case we will within a few years get a system where the number of students in each grade is constant, i.e.

$$N_k^{z+1} = N_k^z .$$

Our first fundamental equation would be:

$$N_1^{z+1} = N_1^z \, w_1^z \, (1 - p_1^z) + M = N_1^z ;$$

$$N_1^z = \frac{M}{1 - w_1^z \, (1 - p_1^z)} .$$

And our second equation runs:

$$N_k^{z+1} = N_k^z w_k^z (1 - p_k^z) + N_{k-1}^z w_{k-1}^z p_{k-1}^z = N_k^z ;$$

$$N_k^z = \frac{N_{k-1}^z w_{k-1}^z p_{k-1}^z}{1 - w_k^z (1 - p_k^z)} .$$

As soon as we know M, w_k^z and p_k^z for all grades, we can compute all values of N_k^z. We are now able to answer the questions we asked at the beginning of this section of the article.

We will illustrate the use of the formulas by means of an example. In the table below we present data about boys in elementary school in Morocco. Morocco has a five-year elementary school system. The necessary parameters are computed.

We are now able to compute the numbers of years studied which are found in the following table.

Table 1. Distribution in 1962/63 of Boys Who Were i Grades 1-5 in 1961/62

Grade	Enrolled 1961/62	Distribution in 1962/63			Rates	
		Repeaters	Drop-Outs	Promoted	w_k^z	p_k^z
1	167282	28791	20941	117550	.875	.803
2	119700	20862	3631	95207	.970	.820
3	191014	22018	28254	140742	.852	.865
4	89624	19759	8496	61369	.905	.756
5	55159	17199	37960	--	.312	--

When constructing this table we put M = 1000, i.e. we study what will happen to a cohort of 1000 boys in the two countries. The first six and five lines in the table indicate how many student years are spent in each grade by these 1000 entrants. The sum, which is evidently the total number of years spent by the 1000 students in elementary school, has also been given. The return for the teaching ought to be equivalent to the total number of students who leave elementary school after having completed its highest grade. Here it has been computed as

$$\text{Number of Graduates} = N_t^z (1 - w_t^z),$$

where t = 5. As can be seen, the number of years studied per graduate is 8.5 for a 5-year cycle. This is internationally not a very high figure.

Table 2. Number of Students in All Grades in A Cohort Where 1000 Students Enter Grade 1 Each Year

Grade	Total Number of Students
1	1207.9
2	1027.9
3	924.2
4	873.6
5	869.1
6	--
Total Number of Years Studied	4902.7
'Graduates'	598.1
No. of Years per Graduate	8.2

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